CONTRIBUTION TO THE STUDY OF THE BIOLOGY OF *STIZUS CONTINUUS* (HYMENOPTERA: SPHECIDAE)[1]

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ABSTRACT: Some aspects of the biology of *Stizus continuus* (Hymenoptera: Sphecidae: Nysoninae) are described. Data on the nest structure, captured prey and behavior of the adults are presented.

Few studies have been conducted on the biology of species in the genus *Stizus* Latreille, 1808, one of the largest in the Nyssoninae. These can be summarized in the works of Feron (1908), Williams (1914), Deleurance (1941), and Tsuneki (1965, 1976). Ferton, Williams and Deleurance refer to captured prey as well as some aspects of the hunting behavior and nest structure of *Stizus fasciatus* (Fabricius. 1781), *Stizus brevipennis* Walsh, 1860 and *Stizus ruficornis* (Forster, 1771). Tsuneki includes a detailed study on the nesting and hunting behavior as well as larval development of *Stizus pulcherrimus* (Smith, 1858). Evans (1966) provides a general review of the ethology of the species and Stubblefield (1984) gives a worldwide list of prey records for *Stizus.*

Considering the little information available on the biology of species in this genus (Stubblefield, 1984), we recently undertook a study of *Stizus continuus* (Klug, 1835). This species is commonly found in sandy areas such as "Dehesa del Saler", an enclave situated in the province of Valencia, Spain, where we located two colonies.

This paper contains the results of field observations, together with some aspects of their behavior observed in captivity. Both field and captivity observations were made from July to September 1985.

MATERIAL AND METHODS

Field observations were conducted at the site of the two colonies in "La Mallada Larga" of "Dehesa del Saler". The dominant vegetation in this area is *Arthrocnemum fruticosum* (Chenopodiaceae), which occurs in great abundance. This species inhabits the coastal salt marshes and dune depressions or "mallaes", which swamp temporarily but also suffer long

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periods of drought, resulting in the formation of saline crusts on the soil during the summer. The resulting texture is damp sand. Other plant species occuring with *Arthrocnemum fruticosum* are, in order of abundance, *Juncus maritimus* (Juncaceae) and *Phragmites australis* (Gramineae). The nests of *Stizus continuus* were grouped in two areas, about 200 m apart.

Captivity studies began on 2 July 1985, when we captured and introduced into an observation cage 2 male and 2 female specimens of *Stizus continuus*. The last of these, a female, died on 30 July 1985. We then captured five more specimens from the same colony (3 males, 2 females) on 5 August 1985. The last of these specimens died on 4 September. The observation cage was placed in the open air where it could receive plenty of sunshine. Inside we placed a small container with honey or sugar diluted with water.

The observation cage used was similar to the one devised by Simon Thomas & Veenendaal (1978) for their studies on the behavior of *Philanthus triangulum* (Fabricius, 1775) (Hymenoptera: Sphecidae). We made some slight changes in the cage so it would serve our purpose better, namely, the lateral perspex sides were replaced with a wire netting to allow better ventilation. We felt that although these insects inhabit very sunny areas, the temperatures that would be reached in an enclosed space exposed to the sun would be so high as to prevent normal activity of the insects.

The observation cage was filled with sand collected from the place where the colony was located. This sand was periodically moistened to avoid excessive dryness which could hinder the normal digging of nests due to the constant crumbling of the burrows. Several potential prey were captured and placed in the observation cage prepared for the wasps.

RESULTS

Data observed in the field.

Imagos started to emerge in June, and as in all Nyssoninae, males usually emerged several days before females. Males made short "sun dances" - sinuous flights 5-10 cm above the ground - during the sunny periods of the day, but most of the time they alighted on the soil and pounced on any other insect that flew sufficiently near. Apparently, they defend the emerging holes and the adjacent areas against other males.

The males in their territory introduced themselves into the emerging holes, and frequently walked, touching the ground with their antennae. This behavior seemed to be directed towards finding the females that were emerging from their cocoons. When that happened, males dug in the sand, often with several males aggregating at the same spot. When the females appeared the males tried to copulate with them, and on several occasions we could see males forming a ball with a female in the center. The behavior of the males seemed to be connected with a strong competition between them to copulate with the females.

The excavation of the nest by the females was similar to that observed in captivity. Once the nest was built, the female went off in search of prey to provision it. Transport of prey was of the mesopedal type, as described below. Upon reaching the nest, the female opened the outer closure with the forelegs, which remained free, and entered with the prey.

The prey captured by the females studied were as follows:

Catantopidae:

Pezzotetix giornae (Rossi, 1794): 3 male nymphs, 7 female nymphs.
Heteracris littoralis (Rambur, 1896): 3 male imagos.
Tropidopola cylindrica cylindrica (Marschall, 1836): 5 male nymphs, 8 female nymphs; 2 male imagos.
Catantopidae 5 undetermined nymphs.

Pyrgomorphidae:

Pyrgomorpha conica (Oliv., 1791): 2 male nymphs, 3 female imagos.

Tettigoniidae:

Homorocoryphus nitidulus (Scopoli, 1786): 5 female imagos.

Prey were deposited in cells with the head towards the end of the cell and the venter upwards.

Various nests were excavated in the colony under study, in some of which provisioning had not been completed. These nests (Plate I, Fig. 5-7) presented a varying number of cells (3-8) ($\bar{x} = 5.5$, $n = 8$), being in general rather shallow and rectilinear. Their length ranged from 35-69 cm ($\bar{x} = 50.1$, $n = 11$), and their depth varied between 8-18 cm ($\bar{x} = 12.7$). In several nests observed, the female had built one or two accessory nests, near the entrance to the burrow. The number of prey deposited in a cell varied from 4 to 8. The egg (3 x 1 mm) was attached to the wing bud of the first prey taken to the nest, with the caudal end fixed to it and the cephalic end free, facing the coxa of the second pair of legs (Plate II, Fig. 1, 2).

It appears that mass provisioning is the rule, that is, prey are brought to the nest by the female before the egg hatches and the larva emerges. However, on three occasions, females were observed taking prey to the nests when the larvae had already hatched and were feeding on the first prey.

The cocoon is long and oval, with a length of 19-25 mm ($\bar{x} = 22$, n =

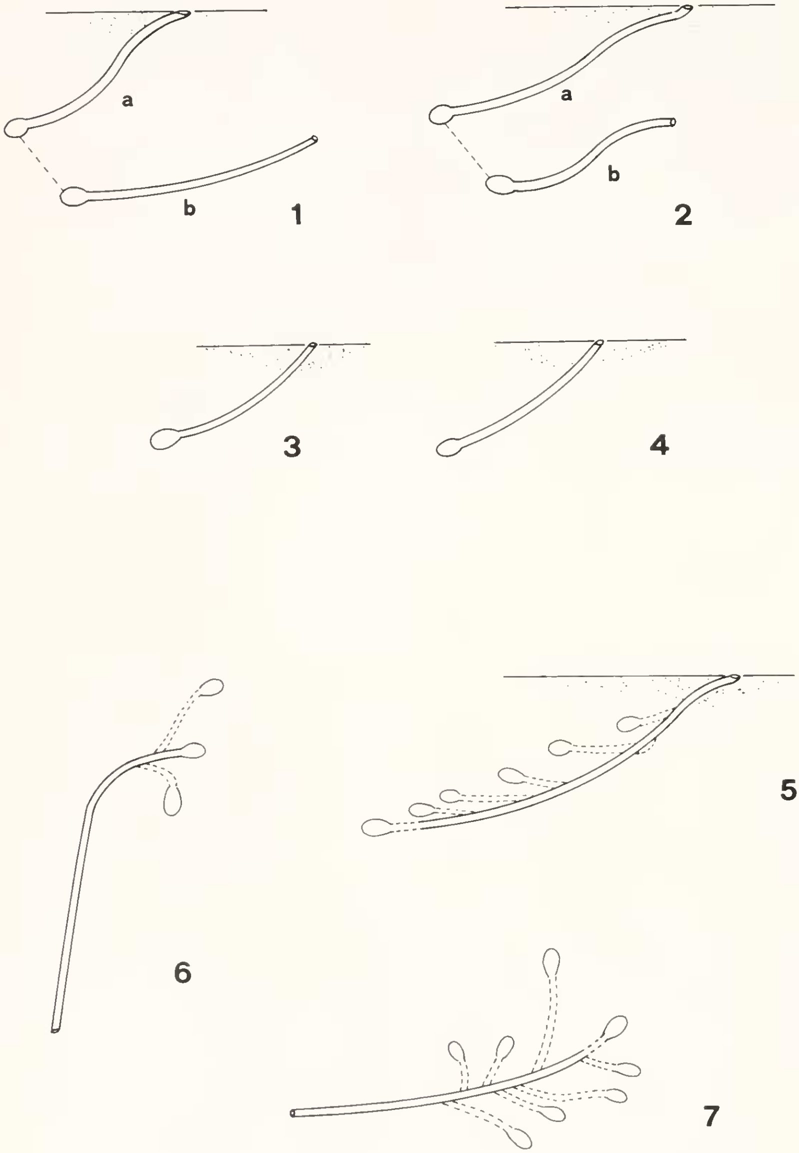
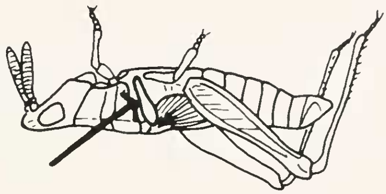


Plate I. Nests of *Stizus continuus* (Klug). Fig. 1-4: Nests made in captivity (a. lateral view; b. dorsal view). Fig. 5-7: Nests dug in the field (5. lateral view, 6 and 7. dorsal views).

10), and a maximum width of 8-10 mm ($\bar{x}$ = 8.6). Towards the posterior end it narrows terminating in a small nipple-like protuberance. It is made from grains of sand of similar size (1.7- 2.1 mm), with some larger grains (up to 4 mm). There are several pores (3-6) ($\bar{x}$ = 4) at the equatorial zone.

Observations made in captivity.

The insects introduced into the cage showed signs of restlessness at first, and made frequent flights, banging repeatedly against the glass. After



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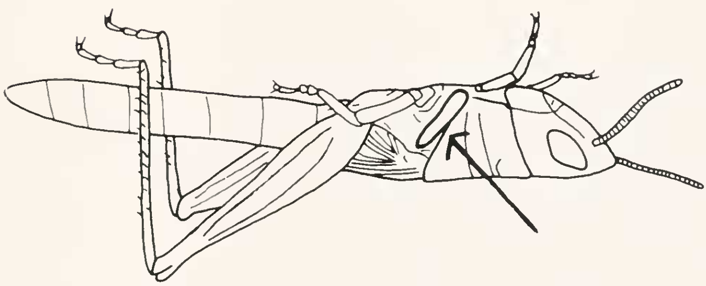

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Plate II. Immature grasshoppers bearing an egg of *Stizus continuus* (Klug). Fig. 1. *Pyrgomorpha conica* (Oliv.). Fig. 2. *Tropiodopola cylindrica cylindrica* (Marschall).

several hours they adapted to the available space and spent most of the time alighted on the wire netting, especially the males.

On the other hand, the females spent a lot of time alighted on the sand. They made frequent motions by moving the foretarsi along the mouthparts first, then along the head and the lateral and ventral parts of the thorax. They often arranged and cleaned their wings with their hind legs. These cleaning motions were also observed when a female was digging a burrow. Only twice did we observe a female spend the night on the soil. As a rule, both males and females spent the night alighted on the wire netting.

Females began digging burrows many times, but often stopped when they had dug a small tunnel measuring 1.5-3 cm. long. Females dug their nests with the forelegs, removing the sand from the burrow with simultaneous movements of the two legs; they also used their mandibles to cut small roots or to remove big sand grains. Nests dug by females in captivity (Plate I, Fig. 1-4) consisted of S-shaped or curved burrows 11-18 cm long ($\bar{x} = 15.4$, $n = 5$). At the end of the burrow there was an oval cell about 2-2.5 cm long ($\bar{x} = 2.1$), and 1-1.5 cm high ($\bar{x} = 1.4$), where prey were deposited. The cell was situated about 8 cm from the surface ($\bar{x} = 7.8$).

To paralyze prey, a female pounces on it and stings it several times in the ventral surface of the thorax, leaving the prey anaesthetized and almost completely paralyzed; the prey moving only its antennae and palpi while being removed. The mode of carrying the prey is the same as described by Tsuneki (1976) for *Stizus pulcherrimus,* that is, the prey is held venter up and head forward by the wasp's middle pair of legs (mesopedal type). The prey captured, paralyzed and deposited in the nests of the females studied in captivity were imagos of *Acrotylus insubricus insubricus* (Scopoli, 1786) (Acrididae).

DISCUSSION

Behavior studied in the field seems similar to that observed in other species of the genus. The behavior of the males, also described by Tsuneki (1976) of *Stizus pulcherrimus*, is quite similar to that described by O'Neill and Evans (1983) for *Bembecinus quinquespinosus* (Say, 1823): males are able to locate and dig up the virgin females, enter and explore the emerging holes, and form "mating balls" around the recently emerged females. This can be explained by the existence of great competition among them to copulate with the females. The territorial behavior they exhibit may produce, as indicated by Lin (1963) for *Sphecius speciosus* Drury, 1773), a spreading of the males which ensures that the majority of the females are fertilized within a short time of their emergence, as well as a reduction of the interference of other males during copulation.

Several important differences were observed between the behavior shown by individuals in the wild and those in captivity. While some patterns remain unchanged (excavation of nest, capture and transport of prey), others do not appear in captivity: in no case were the females seen to take more than one item of prey to the cell, nor did they lay eggs, nor build more than one cell per nest. These three patterns could be related to the way in which the interruption of the cycle at the moment of laying will impede the continuation of the process, no new prey being brought (given that laying is performed upon the first prey brought to the nest) nor any new cells being dug in the nest. Without doubt, in abnormal situations such as captivity, given the presence of stimuli (and/or the absence of others) different to those present in the natural state, the behavior is modified, with the possibility of multiple factors impeding completion of the nesting process, detaining it at a determined moment.

It would appear that in the genus *Stizus,* mass provisioning is the rule, although both Tsuneki (1965) for *Stizus pulcherrimus*, and ourselves for *Stizus continuus* have found some exceptions. As indicated previously, upon excavation of three nests being provisioned by the females, we were able to extract small larvae which were feeding on one of the prey; a similar case was described by Tsuneki (1965). As, in both cases, the weather had been good during the previous days, there is no apparent reason for a delay in provisioning. Tsuneki (1965) considered that the Mongolian population of *Stizus pulcherrimus* exhibited a progressive provisioning, albeit of a primitive type. At any rate, following the criterium of Genise (1982), in order to consider it as such, a continuous contact between the larva and the female would have to exist, a contact which has not been proven to exist and which would seem difficult to conceive, given that the larva, at birth, is situated on the prey located nearest the bottom. We believe that, as a rule, mass provisioning could be the norm, although perhaps the rhythm of prey delivery, probably regulated by internal factors, is not very rapid. In some cases, situations may arise in which the larva may emerge before the female has completed provisioning the nest. In this way, and using the classification proposed by Genise (1982), such behavior would represent a "slow mass provisioning". These data probably confirm the hypothesis of Evans (1955), who proposed that within the genus *Stizus* there may be species which exhibit delayed provisioning, as seems to be the case in this instance.

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